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Accommodation During Instrument Viewing Can Be Influenced By Knowledge of Object Distance
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The level of accommodation during instrument viewing is influenced by the perceived nearness of the object in subjects with proximal, but not distal, dark focuses.

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ACCOMMODATION DURING INSTRUMENT VIEWING CAN BE INFLUENCED BY KNOWLEDGE OF OBJECT DISTANCE

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INTRODUCTION

Instrument myopia generally is thought to arise from excessive accommodation.[1,2] Although the level of instrument accommodation is known to be influenced by physiological factors, such as the tendency of accommodation to seek its resting point or dark focus when the feedback loop is opened by a small exit pupil, the contribution of psychological factors, such as perceived nearness, is still debated.[3-5] Some investigators have found that perceived distance has no effect on accommodation under ordinary, closed loop conditions,[3,6,7] and others have found the opposite when the feedback loop is open.[8-10] However, the feedback loop during instrument viewing probably exists mostly in an intermediate state which is neither completely closed nor completely open, because factors such as decreased luminance and small exit pupil size partially open the loop.[3-5] We call this intermediate condition "semi-open" loop. In this paper, we describe an experiment in which accommodation was measured during instrument viewing while the feedback loop was semi-open. During this experiment, object distance was varied but accommodative demand was held constant at infinity. Our purpose was to determine if perceived nearness affects instrument accommodation under realistic viewing conditions.

METHODS

The optical instrument was a pair of binocular night vision goggles with unity magnification, which electronically amplify ambient light and provide a photopic visual display under night sky conditions. The night vision goggle image creates the semi-open loop conditions which we desired for this experiment because of its relatively low luminance (1 cd/m^2), its low spatial frequency content (the -3 dB rolloff of the spatial modulation transfer function is at 5 cycles/degree), and the presence of uncorrelated dynamic visual noise.[11] The visual stimulus was a Bailey-Lovie visual acuity chart, which provides targets of the same visual angle at each test distance that was used in the experiment (6, 1, 0.5, and 0.33 m). Accommodation was measured

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monocularly under steady-state conditions with a dynamic infrared optometer. The steady-state values were calculated from the mean of 600 samples (20 samples/sec X 30 sec/trial). Dark focus was obtained in a similar fashion. Object distance was varied randomly over the test range, while image distance, size, luminance, and contrast were held constant. The instrument eyepieces were set to 0.0 D and the objective lenses were focused for the object distance. The subject was informed of object distance and was instructed to observe as the test distance was measured out. The subject's task was to view through the instrument and keep threshold sized letters clear. Seven young adult volunteer subjects were used. All subjects were either 20/20 or corrected to 20/20 for the target distance, and were free from eye disease or other ocular anomalies.

RESULTS

Figure 1, in which each plot represents a different subject, shows how instrument accommodation varied with object distance.

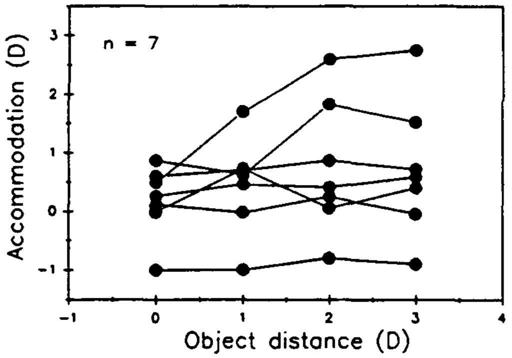

Figure 1. Accommodation as a function of object distance when the data of each subject are shown individually.

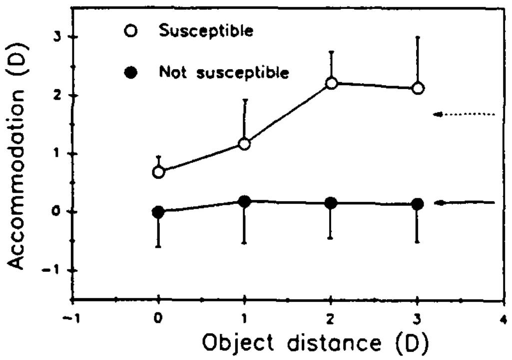

Figure 2. Accommodation as a function of object distance when the subjects are grouped according to susceptibility to proximal cues.

Negative values of accommodation represent accommodation which is less than that required to fully compensate for a hyperopic refractive error. The subjects seem to fall into two distinct groups, i.e., those affected by changes in object distance (n = 2), and those unaffected (n = 5). The affected subjects readily perceived target blur at the nearer object distances, but reported that they were unable to eliminate the blur, even through voluntary effort. In Fig. 2, the responses of the subjects within each group are averaged, and the mean dark focus of each group is shown. The error bars indicate one standard deviation. The dotted line with arrow indicates the mean dark focus of the susceptible group, while the solid line with arrow indicates the mean dark focus of the non-susceptible group. Thus, the group with the more proximal dark focus is the one that was affected by changes in object distance.

The subject who exhibited the most susceptibility to the effect of object distance was retested on a subsequent day. There was no statistically significant difference in instrument accommodation for this subject between the two days ($t = 1.23$, $p = 0.31$). In addition, the dark focus of each subject was measured immediately pre and post test. There was no evidence of a change in dark focus ($t = 0.33$, $p = 0.75$).

DISCUSSION

Our results indicate that knowledge of object distance can influence the level of accommodation under semi-open loop conditions. This is predictable from earlier works which showed no proximal effect for closed loop conditions, but a pronounced effect for open loop conditions. Perhaps more significant is the fact that the proximal effect appears to be all or none, rather than graded. This is not predictable from previous studies, and neither is the apparent relationship between susceptibility to the proximal effect and dark focus magnitude.

An explanation for the latter is not readily apparent from existing theory. However, we offer the following hypothesis. Fisher and Ciuffreda[12,13] have established a link between dark focus and distance perception, such that distance information is derived from the amount of blur-driven accommodation relative to the dark focus. Morse and Smith[14] have demonstrated that dark focus variability is proportional to its magnitude. Subjects with more proximal dark focuses might not be able to reliably obtain distance estimates from accommodation due to greater fluctuations in dark focus. Perhaps accommodation, if it is deprived of a role in distance perception, might itself be vulnerable to the influence of perceived distance cues from other modalities.

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